ATTACHMENT 7

ECONOMIC ANALYSIS:
FLOOD DAMAGE REDUCTION COSTS AND BENEFITS

1. Description of the Project and its relationship to other Projects

The project includes both the North Drainage Basin C Regional Detention Basin and the associated pumping facilities. Reclamation District (RD) 784 has previously constructed the North Drainage Basin C Regional Detention pond as part of the project and now seeks funding to complete the discharge pumping facilities to complete the project. RD 784 is requesting credit toward the local share of the project for the prior completed work; therefore RD 784 is requesting funding for the entire detention basin and associated pumping facilities.

As described within the IRWMP as projects ST 13 and ST 14, the projects are described as follows:

Reclamation District (RD) 784 encompasses a drainage area of approximately 17,000 acres within the County of Yuba and is roughly bounded by the Yuba River to the north, the Bear River to the south, the Feather River to the west, and the Western Pacific Interceptor Canal to the east. Within its watershed, RD 784 operates a system of drainage laterals that convey storm runoff to a number of pumping plants that discharge the runoff outside of the District's boundaries. Pump Station No. 10 will be part of this system, discharging runoff for the 5,200-acre Basin C in the northeast part of the district.

A Drainage Master Plan for RD 784 (Master Plan) was prepared in September 2002. The purpose of the Master Plan was to develop a comprehensive plan to ensure proper implementation of drainage facilities for all of RD 784.

The Master Plan proposed improvements to the numerous pump stations in RD 784. RD 784 established a policy to require all new pump stations to have a SCADA system, a redundant pump, and backup generator. The policy is based on past experience where two pumps, Pump Station No. 2 and Pump Station No. 9, lost power during a major storm event resulting in additional flooding. The SCADA system will allow RD 784 to operate and monitor the pumps and motors from a remote location. It will also alert district personnel of a power outage or operation problem immediately.

The Pump Station 10 Project includes construction of a new 60 cubic feet per second (cfs) pump station with a redundant pump and backup generator. The pump station will remove the water from the North Drainage Basin C Regional Detention Pond and pump the water directly to the Feather River in the vicinity of Pump Station No. 9. As required by the Master Plan, a SCADA system will be installed with this new pumping facility. The pump station will alleviate loads on existing pumps No. 6 and No. 9 during flood events and, thus, will contribute to regional flood and stormwater management objectives.

The expansion of the regional detention basin in conjunction with the above described pumping facilities will help remove property from 100-Year flood pain.

2. Description of Project's Costs

As part of RD 784's Drainage Basin C Improvement Fee Study, RD 784 has studied the costs of the project. RD 784 has adapted these costs to the format required within **Tables 6** and **10** and is requesting funding for 50% of the project costs through the IRWM Grant Funding Program for SWFM.

The total costs of the North Drainage Basin C Regional Detention Basin and Pump Station 10 project as shown in **Table 6** in 2009 dollars are $15,469,961. In order to derive the estimates, for the components of the project that have previously been completed, actual costs incurred by RD 784 have been inflated using ENR Cost indices which is standard practice for the District as part of its Drainage Fee program. All prior costs incurred by the District for this project have been incurred after September 30, 2008. For the remaining components of the project, primarily the Pump Station 10 and transmission pipe work, detailed estimates have been prepared by the District's Engineer and are the basis for the costs.

Table 10 presents the cost information summarized in **Table 6** in terms of present value costs for comparison to the flood damage reduction benefits. RD 784 is presenting the costs in 2009 dollars as required by Exhibit C of the PSP.

Added to the project costs from **Table 6** are the following costs:

- Administrative costs of the project are estimated to be $2,500 per year
- Operations costs of $48,950 per year
- Maintenance costs of $18,950 per year
- Replacement Costs are estimated to be $37,500 every 10 years and $490,000 after 25 years.

These above costs are budget estimates prepared by the District's Engineer and General Manager based upon completion of the detailed budget estimates and Life-Cycle Analysis. These detailed estimates are attached to this document at Exhibit A. The project is expected to have a useful life of 50-Years, thus the analysis in **Table 10** has been completed for this time frame.

The total discounted Project Costs summarized in **Table 10** in 2009$ are $15,067,331.

3. Description of Project's Benefits

As previously described, the project is a flood management project with the objective of reducing internal flooding within Drainage Basin C. An analysis of the flood damage reduction benefits of the project has been completed by David Ford Consulting Engineer's. This analysis has been prepared to conform to the requirements outlined within Exhibit C of PSP.

The results of their analysis have been summarized in their memorandum dated April 14, 2011 attached as Exhibit B to this document. The analysis concludes that project provides a flood damage reduction benefit of $2,128,000. This information has been transferred to **Table 20** in Attachment 10 (as described in Exhibit F) as required by the PSP.

EXHIBIT A

Reclamation District No. 784
1594 Broadway
Marysville, CA 95901

BILL TO: Reclamation District No. 784
c/o MHM, Inc.
523 J Street, P.O. Box B
Marysville, CA 95901

DATE PERFORMED: Annual

DATE OF REPORT:

DESCRIPTION OF WORK: Annual Maintaince of Pond/Pump Station
Reclamation District No. 784

REPORT NO.: 1

	EQUIPMENT	HRS	RATE	AMOUNT
1	Tractor <50 Hp with Mower	80.0	16.38	1,310.40
2	CAT 416D w/backhoe	24.0	29.60	710.40
3	Truck & Lowbed	16.0	31.03	496.48
4	F250 Ford Pickup	24.0	13.54	324.96
5	10 Yd Dump Truck	16.0	29.86	477.76
6				
7				
8				
9				
10				
11				
12				
	EQUIPMENT SUBTOTAL			3,320.00

EQUIPMENT, MATERIAL & RENTAL

	DESCRIPTION	No. Units	Unit Cost	Cost for Item
1	Chemicals	1.0	2,000.00	2,000.00
2				0.00
3				
4				
5				
6				
7				
8				
9				
	INVOICE SUBTOTAL			2,000.00

MATERIALS FOR SPECIALTY WORK

	DESCRIPTION	No. Units	Unit Cost	Cost for Item
1				
2				
3				
4				
5				
6				
7				
8				
9				
	INVOICE SUBTOTAL			0.00

	PRIME CONTR. LABOR (NAME)	HOURS R/T	HOURS O/T	RATE R/T	RATE O/T	AMOUNT R/T	AMOUNT O/T
1	Foreman	24.0		47.40	62.59	1,137.60	
2	Tractor Operator	80.0		44.81	58.71	3,584.80	
3	Loader Operator	24.0		47.40	62.59	1,137.60	
4	Labor	80.0		33.36	44.31	2,668.80	
5							
6							
			SUBTOTAL			8,528.80	0.00

	PRIME CONTR. LABOR (NAME)	HOURS R/T	HOURS O/T	RATE R/T	RATE O/T	AMOUNT R/T	AMOUNT O/T
1							
2							
3							
4							
5							
6							
			SUBTOTAL			0.00	0.00

Add Payroll Burden Percentage		13.00%	12.00%
	Prime Contractor Labor	1,108.74	0.00
Travel Expense			0.00
Total Cost of Prime Contractor Labor		(A)	9,637.54
Total Cost for Equipment, Materials, and Rental		(B)	5,320.00
Total Cost for Specialty Materials and Equipment		(C)	0.00
Total Cost for Specialty Labor		(D)	0.00
33.00%	Markup On Labor Cost		3,180.39
15.00%	Markup On Equip. & Inv.		798.00
38.00%	Markup On Labor		0.00
20.00%	Markup On Material for Specialty Work		0.00
	TOTAL THIS REPORT	$	18,935.93

ACKNOWLEDGED BY: RECLAMATION DISTRICT NO. 784

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EXHIBIT A

Reclamation District No. 784
1594 Broadway
Marysville, CA 95901

BILL TO: Reclamation District No. 784
c/o MHM, Inc.
523 J Street, P.O. Box B
Marysville, CA 95901

DATE PERFORMED: Annual

DATE OF REPORT:

DESCRIPTION OF WORK: Annual Operation of Pond/Pump Station
Reclamation District No. 784

REPORT NO.: 1

	EQUIPMENT	HRS	RATE	AMOUNT
1	F250 Ford Pickup	100.0	13.54	1,354.00
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
	EQUIPMENT SUBTOTAL			1,354.00

EQUIPMENT, MATERIAL & RENTAL

	DESCRIPTION	No. Units	Unit Cost	Cost for Item
1	PG&E Electric Cost	1.0	24,000.00	24,000.00
2	Generator	1.0	5,000.00	5,000.00
3	Fuel	1.0	5,500.00	5,500.00
4				
5				
6				
7				
8				
9				
	INVOICE SUBTOTAL			34,500.00

MATERIALS FOR SPECIALTY WORK

	DESCRIPTION	No. Units	Unit Cost	Cost for Item
1				
2				
3				
4				
5				
6				
7				
8				
9				
	INVOICE SUBTOTAL			0.00

	PRIME CONTR. LABOR (NAME)	HOURS R/T	HOURS O/T	RATE R/T	RATE O/T	AMOUNT R/T	AMOUNT O/T
1	Foreman	80.0		47.40	62.59	3,792.00	
2	Labor	40.0		33.36	44.31	1,334.40	
3							
4							
5							
6							
	SUBTOTAL					5,126.40	0.00

	PRIME CONTR. LABOR (NAME)	HOURS R/T	HOURS O/T	RATE R/T	RATE O/T	AMOUNT R/T	AMOUNT O/T
1							
2							
3							
4							
5							
6							
	SUBTOTAL					0.00	0.00

Add Payroll Burden Percentage	13.00%	12.00%
Prime Contractor Labor	666.43	0.00
Travel Expense		0.00
Total Cost of Prime Contractor Labor	(A)	5,792.83
Total Cost for Equipment, Materials, and Rental	(B)	35,854.00
Total Cost for Specialty Materials and Equipment	(C)	0.00
Total Cost for Specialty Labor	(D)	0.00
33.00% Markup On Labor Cost		1,911.63
15.00% Markup On Equip. & Inv.		5,378.10
38.00% Markup On Labor		0.00
20.00% Markup On Material for Specialty Work		0.00
TOTAL THIS REPORT		$ 48,936.57

ACKNOWLEDGED BY: ____________________

RECLAMATION DISTRICT NO. 784 ____________________

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Table No. 1 - Life Cycle Cost
50-Year Analysis Period and 6% Discount Rate

EXHIBIT A

Initial Cost					$ 15,908,144.34
Replacement Cost for Aggregate Base Surface					
Cost				$ 29,765.63	
Engineering	29,765.63	x 0.1225		3,646.29	
Appurtenant Work	29,765.63	x 0.1350		4,018.36	
Traffic Delay				0.00	
		subtotal =		$37,430.27	
Present Worth of AB Replacement (10 year)		37,430.27 x	0.5584		20,900.87
Present Worth of AB Replacement (20 year)		37,430.27 x	0.3118		11,670.94
Present Worth of AB Replacement (30 year)		37,430.27 x	0.1741		6,516.99
Present Worth of AB Replacement (40 year)		37,430.27 x	0.0972		3,639.05
Replacement Cost for Chain Link Fencing in Current Dollars					
Cost				$ 127,000.00	
Engineering	127,000.00	x 0.1225		15,557.50	
Appurtenant Work	127,000.00	x 0.1350		17,145.00	
Traffic Delay				0.00	
		subtotal =		$159,702.50	
Present Worth of Fence Replacement (25 year)		159,702.50 x	0.2330		37,210.46
Replacement Cost for Electric Motors and Pumps in Current Dollars					
Cost				$ 390,000.00	
Engineering	390,000.00	x 0.1225		47,775.00	
Appurtenant Work	390,000.00	x 0.1350		52,650.00	
Traffic Delay				0.00	
		subtotal =		$490,425.00	
Present Worth of Pump/Motor Replacement (25 year)		490,425.00 x	0.2330		114,268.35
~~**Replacement Cost for Buildings in Current Dollars**~~					
~~Cost~~				~~$ 0.00~~	
~~Engineering~~	~~0.00~~	~~x 0.1225~~		~~0.00~~	
~~Appurtenant Work~~	~~0.00~~	~~x 0.1350~~		~~0.00~~	
~~Traffic Delay~~				~~0.00~~	
		~~subtotal =~~		~~$0.00~~	
~~Present Worth of Buildings Replacement (50 year)~~		~~0.00 x~~	~~0.0543~~		~~0.00~~

Table No. 1 - Life Cycle Cost
50-Year Analysis Period and 6% Discount Rate

EXHIBIT A

~~Replacement Cost for Discharge/Outfall Pipe in Current Dollars~~					
~~Cost~~				~~$ 0.00~~	
~~Engineering~~	~~0.00~~	~~x 0.1225~~		~~0.00~~	
~~Appurtenant Work~~	~~0.00~~	~~x 0.1350~~		~~0.00~~	
~~Traffic Delay~~					
		~~subtotal =~~		~~$0.00~~	
~~Present Worth of Discharge Pipe Replacement (50 year)~~		~~0.00~~ ~~x~~	~~0.0543~~		~~0.00~~
~~Replacement Cost for Pump Station Structure in Current Dollars~~					
~~Cost~~				~~$ 0.00~~	
~~Engineering~~	~~0.00~~	~~x 0.1225~~		~~0.00~~	
~~Appurtenant Work~~	~~0.00~~	~~x 0.1350~~		~~0.00~~	
~~Traffic Delay~~				~~0.00~~	
		~~subtotal =~~		~~$0.00~~	
~~Present Worth of Pump Station Replacement (50 year)~~		~~0.00~~ ~~x~~	~~0.0543~~		~~0.00~~
Operation for 50 years		18,935.93 x	15.7619		298,465.49
Maintenance for 50 years		33,986.57 x	15.7619		535,691.58
					$ 16,936,508.07

Annual Amount Required = $1,074,524.67

David Ford Consulting Engineers, Inc.

2015 J Street, Suite 200
Sacramento, CA 95811

Ph. 916.447.8779
Fx. 916.447.8780

MEMORANDUM

To: Steve Fordice
Reclamation District No. 784

From: Nathan Pingel, PE and Natalie King, PE

Date: April 14, 2011

Subject: Inundation-reduction (IR) benefit analysis for regional drainage facility in Reclamation District No. 784, pump station No. 10 and Ella regional detention basin, in support of California Department of Water Resources (DWR) Integrated Regional Water Management (IRWM) grant application

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Situation

Reclamation District No. 784 (RD784) is designing a regional drainage facility that services an area of approximately 16,500 acres within Yuba County. This area is roughly bound by the community of Linda to the north, State Route 70 to the east, the Bear River to the south, and the Feather River to the west. Further details regarding the area and the project design and features are included in the *Technical Memorandum regarding the Regional Drainage Facility which includes Pump Station No. 10 and the Ella Regional Detention Basin, Yuba County, California* (MHM Incorporated 2009) and is herein referred to as the *Project description*.

As part of the Department of Water Resources (DWR) Integrated Regional Water Management (IRWM) grant application, an inundation-reduction (IR) benefit analysis is required.

IR benefit concept

The IR benefit is defined as the value of damage prevented: damage incurred without the project less damage incurred with the project in place. For example, if a flood would cause $1 million damage to property in an impact area without the proposed damage-reduction features, and if that same flood would cause only $0.4 million with the project, then the IR benefit (the money saved due to the project) is $0.6 million for that flood.

In urban settings, flood damage analysis traditionally is restricted to an accounting of damage due to the largest event that occurs each year, a restriction that we use here. Clearly more than a single damaging flood could occur in a year. However, the time required for recovery, repair, and reconstruction will limit the loss incurred by a second or third flood, so the total loss in the year is most likely a function of the largest of the floods.

Of course, in some years, no flooding will occur. In that case, a flood-damage reduction project will provide little or no benefit. In other years, large floods could cause significant damage, so by protecting people and property, the project will yield a great benefit. The random nature of flooding makes it impossible to predict the damage prevented in any particular year of the project's life because we can't predict flood flows years in advance. Consequently, for evaluation of flood-damage-reduction plan performance, the *Economic and environmental principles and guidelines for water and related land resources implementation studies* (US Water Resources Council 1983) stipulates use of the statistical average damage value. This average is known commonly as the expected annual damage (EAD).

Task

Our task was to answer the question: what is the IR benefit for the RD784 regional drainage facility project?

Analysis procedure

To answer this question, we followed the State's and Corps' economic analysis procedures, incorporating uncertainty analysis. (Hereinafter, we refer to this analysis as the IR benefit analysis). For evaluation of the RD784 project, we computed EAD for without- and with-project conditions in the study area. The difference is the expected annual IR benefit.

We computed EAD using the statistical sampling procedure developed by the Corps (USACE 1996). This commonly is known as the risk and uncertainty analysis procedure, or R&U. This procedure is included in the Corps' computer program HEC-FDA. To compute EAD with HEC-FDA, the following are required:

- Elevation-probability function for each index point. This describes the annual probability or frequency of water surface in the river (exterior channel) reaching a specified elevation.
- Exterior-interior elevation function for each damage reach (impact area). This function relates the water surface elevation in the channel (exterior) at the index point to the elevation of flooding in the floodplain adjacent to the channel (interior).
- Elevation-damage function for each damage reach. This function relates economic damage in the floodplain to floodplain (interior) water surface elevation.

Action

To compute EAD and IR benefits here, we:

1. Coordinated with the project team to define the conditions of the study, including the without-project condition and the with-project condition. Here, the project includes both the pump station No. 10 and the Ella regional detention basin.
2. Identified the benefit analysis area. Here, in coordination with the project team, the benefit analysis area was defined as the area and structures within the without-project condition p=0.005 floodplain extent. The benefit analysis area is shown in Figure 1. This floodplain extent was developed by MHM Incorporated.
3. Identified damage reaches for the IR benefit analysis area. The damage reaches are subareas within the benefit analysis area. A damage reach is defined by a stream segment and an upstream and downstream cross section. In later parts of the analysis, structures in the study area are

related to cross sections within a damage reach used for the study. The damage reaches used herein are listed in Attachment B.

4. Identified index points for each damage reach. The hydrologic and hydraulic characteristics of a damage reach are represented by those characteristics at the index point. The index points used for the analysis are listed in Attachment B.

5. Obtained the required hydrologic and hydraulic input for each index point and damage reach from MHM Incorporated. For this, we obtained water surface profiles for both the without- and with-project conditions for the p=0.5, 0.1, 0.04, 0.02, 0.01, 0.005 events. Details of the hydrologic and hydraulic analysis are available from MHM Incorporated. For completeness, we linearly interpolated the provided inputs to find the p=0.999 and the p=0.2 event water surface elevations.

6. Developed the required exterior-interior elevation functions for each damage reach. For this, the hydraulic analysis provided by MHM Incorporated found that the floodplain elevation is the same as the channel elevation. Thus, the exterior-interior function is a one-to-one relationship.

7. Developed an elevation-damage function for each damage reach. For this, we relied on structure inventory information developed for the *Three Rivers Levee Improvement Authority (TRLIA) Phase IV: Feather River levee repair project benefit report* (TRLIA 2006). Specifically, we used the identified structures in the inventory, structure values, content values, structure categories, depth-% damage functions, and structure elevations from the 2006 study.

   The reported values in the 2006 TRLIA report are in 2006 dollars, however the valuation of the inventory was completed in 2004. Cost indices were used to develop the reported 2006 dollars. For this analysis, we updated the structure values from 2004 dollars to 2009 dollars using the update factors provided in Table 9 of the IRWM proposal solicitation package (DWR 2010).

   As noted above, a required step in developing the elevation-damage function is to relate each of the structures in the study area to a cross section within a defined damage reach. For this, we used information on hydraulic model cross sections from MHM Incorporated, geographic information system (GIS) tools, and available aerial photographs. Based on the available information, we identified and assigned to each structure the cross section that best represented the water surface elevations at that structure.

8. Configured computer program HEC-FDA to use the information developed in the previous steps.

9. Computed expected annual damages (EAD) for each damage reach and for the study area as a whole using computer program HEC-FDA.

10. Computed the IR benefit for the study area.

Details of the EAD computations and HEC-FDA model configuration are included in Attachment A. Attachment B lists the hydrologic and hydraulic inputs and a summary of the structure inventory used in the EAD analysis.

Result

Table 1 shows total EAD values computed for without- and with-project conditions for the current floodplain property. The EAD values shown include damages to structures, content, automobiles, and landscaping. Column 3 of the table shows the corresponding annual IR benefit, computed as the difference between with- and without-project EAD. Using a 50-year period of economic analysis and the current State discount rate of 6.0%, the present value of the IR benefit is shown in column 4. The present value of the IR benefit is the accrued benefit over the life of the project.

Although not quantified here, the project does provide other benefits to infrastructure and crops, and reduced displacement and temporary housing costs. Given that this project reduces the p=0.01 event floodplain, the project also results in savings to the administration of the National Flood Insurance Program (NFIP). Consistent with EGM 06-04 (USACE 2006), the annual savings (project benefit) in the NFIP administration is $192 per structure. Based on the *Project description* (MHM Incorporated 2009), 130 structures would benefit from the regional drainage facility. If 130 structures do not require NFIP flood insurance, this results in an annual savings in NFIP administration of approximately $25 thousand. The present value benefit is $394 thousand, given the same period of economic analysis and discount rate. Table 2 summarizes this additional annual benefit along with the annual IR damage benefit from Table 1. Column 4 of Table 2 shows the overall present value project benefit.

Table 1. Expected annual flood-damage and IR benefit

Project plan (1)	EAD[1,2] ($1,000) (2)	Annual value IR benefit ($1,000) (3)	Present value IR benefit[3] ($1,000) (4)
Without-project condition	621	—	—
With-project condition	511	110	1,734

1. EAD values include damage to structures, content, automobiles, and landscaping.
2. Values reported are in 2009 dollars.
3. Present value computed using State discount rate of 6.0% and a 50-year period of economic analysis, or 15.76 (DWR 2010).

Table 2. Total expected annual flood-damage and NFIP administration, and present value project benefit

Project plan (1)	EAD and NFIP administration[1,2] ($1,000) (2)	Annual value benefit ($1,000) (3)	Present value benefit[3] ($1,000) (4)
Without-project condition	646[4]	—	—
With-project condition	511	135	2,128

1. EAD values include damage to structures, content, automobiles, and landscaping.
2. Values reported are in 2009 dollars.
3. Present value computed using State discount rate of 6.0% and a 50-year period of economic analysis, or 15.76 (DWR 2010).
4. Value sums NFIP administration cost for 130 structures and EAD from Table 1.

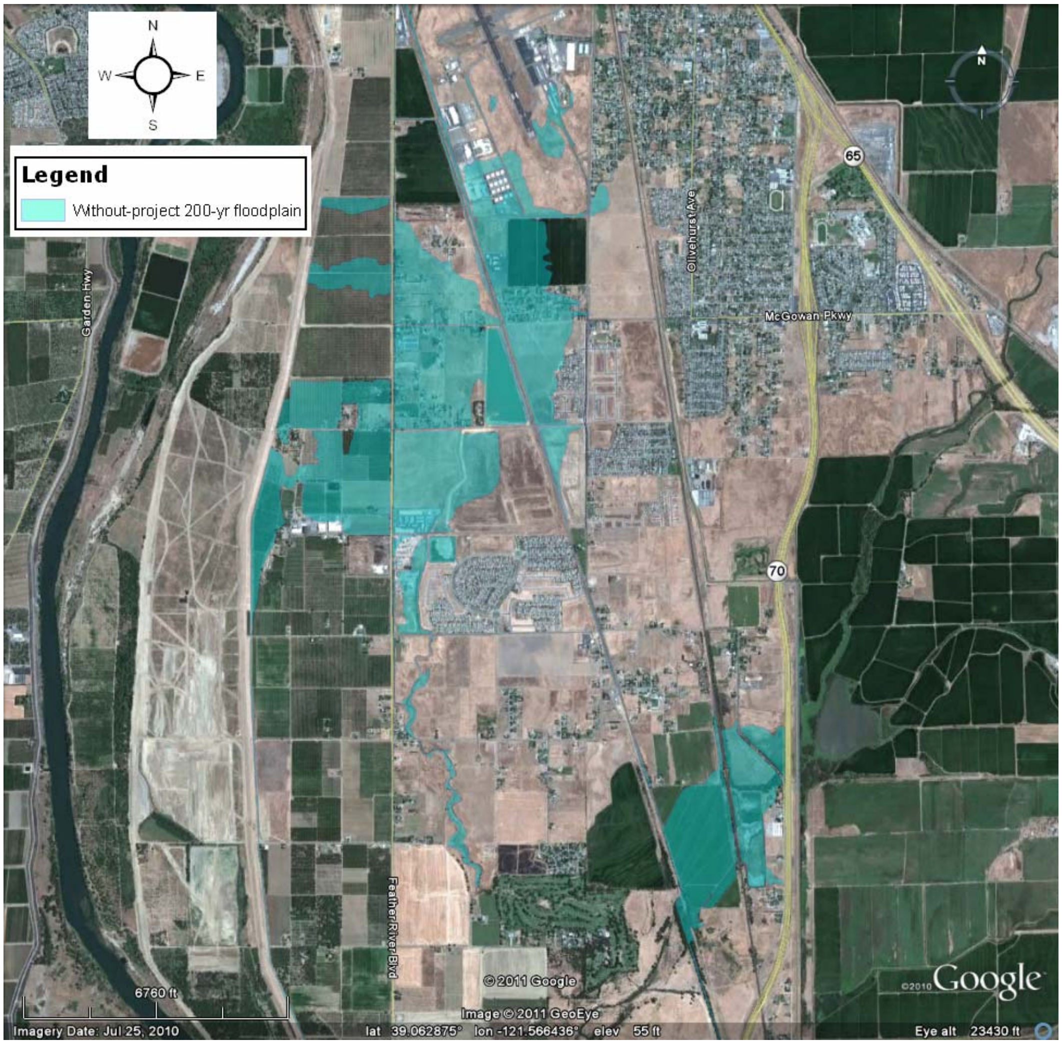

Figure 1. IR benefit analysis study area (Image source: Google Earth map, Geo Eye, 2011)

References

Department of Water Resources (DWR). (2010). *Integrated Regional Water Management grant program: Proposal solicitation package for stormwater flood management grants, Round 1,* Available at <http://www.water.ca.gov/irwm/integregio_implementation.cfm>.

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US Army Corps of Engineers (USACE). (1996). *EM 1110-2-1619 Risk-based analysis for flood damage-reduction studies,* Office of the Chief of Engineers, Washington, DC.

USACE. (2006). *Economic guidance memorandum 06-04, National flood insurance program operating costs FY 2006,* Office of the Chief of Planning and Policy Division, Washington, DC.

USACE. (2007). *Draft economic reevaluation report: American River watershed project, Folsom Dam modification and Folsom Dam raise projects,* Sacramento District, Sacramento, CA.

US Water Resource Council. (1983). *Economic and environmental principles and guidelines for water and related land resources implementation studies,* Institute for Water Resources, Washington, DC.

Attachment A. Flood damage analysis overview

For the RD784 IR benefit analysis, we followed State and Corps economic analysis procedures, incorporating uncertainty analysis. These incorporate the best-available hydrologic, hydraulic, geotechnical (if appropriate), and economic information to compute expected annual damage (EAD), accounting explicitly for uncertainty in the information.

Table 3 summarizes key aspects of this IR benefit analysis as well as key inputs and information sources.

Table 3. Summary of RD784 IR benefit analysis procedure

Aspect (1)	**Details (2)**
Computer model used for EAD computations	HEC-FDA version 1.2.5a. This computer program is available at <http://www.hec.usace.army.mil/software/hec-fda/downloads.html>
Characterization of hydrologic and hydraulic inputs in risk modeling framework	Specified a "graphical" channel elevation-probability function based on the provided water surface profiles. The peak channel elevations for the probability function were developed based on simulations of design precipitation events and use of an unsteady-flow channel model (HEC-RAS). All hydraulic model simulations were completed by MHM Incorporated and provided on April 4, 2011.
Source of structure inventory	The structure inventory used here was extracted from a larger study in the area, the *Three Rivers Levee Improvement Authority (TRLIA) Phase IV: Feather River levee repair project benefit report* (TRLIA 2006). From this previous study, we obtained the structure inventory for this current study. The structure inventory included structure identification, categorization, and valuation. In addition, the structure first-floor elevations used here are based on those used for the 2006 study. As noted in the TRLIA report, the development of the structure inventory, and notably the structure and content values, were based on information developed by the Corps as part of their analyses within the study area. The elevations used for this analysis are in NGVD1929.
Source of depth-percent damage functions	The depth-percent damage functions used here are consistent with those from the 2006 TRLIA analysis. For reference, the depth-percent damage functions are transformed to elevation-damage functions by multiplying the percent damage values by the total value and by adding the first floor elevation to depths.
Description of uncertainties	In HEC-FDA, we described uncertainty in the following inputs: • Graphical elevation-probability function using an equivalent record length = 30 years, consistent with EM 1110-2-1619 (USACE 1996). • Elevation-damage relationships using descriptions of the uncertainty in the various components used to develop the relationship consistent with the 2006 TRLIA analysis (TRLIA 2006). Specifically, uncertainty was described for structure value, % damage given a flood depth, and first-floor elevation.

Attachment B. RD784 IR benefit hydrologic, hydraulic, and economic inputs

As noted in Table 3, the hydrologic and hydraulic inputs used for the analysis were developed by MHM Incorporated. The structure inventory used for the analysis was based on the 2006 TRLIA analysis.

The following tables list the hydrologic and hydraulic inputs used for the analysis as well as provide a summary of the structure inventory and HEC-FDA configuration used. Specifically, tables include:

- Summary of damage reaches and index points, shown in Table 4.
- Summary of the structure inventory used (structures within the without-project condition p=0.005 floodplain), shown in Table 5.
- Without- and with-project condition channel elevation-probability function, shown in Table 6 through Table 15.

Table 4. Damage reach and index point summary

Index point (1)	Stream (2)	Damage reach (3)	Damage reach beginning station (4)	Damage reach ending station (5)	Index point station (6)	Number of associated structures (7)
IP1	CS-PLC	CSPLC_4.603	1.098	4.604	4.603	1
IP2	CS-PLC	CSPLC_5.366	4.605	5.587	5.366	6
IP3	Lateral 13	L13_6.008	5.59	6.009	6.008	1
IP4	Lateral 13	L13_6.346	6.01	7.172	6.346	1
IP5	Lateral 14	L14_1.51	0.003	1.52	1.51	32
IP6	Lateral 14	L14_1.684	1.53	1.685	1.684	9
IP7	Lateral 14	L14_1.824	1.686	1.825	1.824	5
IP8	Lateral 14	L14_1.897	1.826	1.898	1.897	14
IP9	Lateral 14	L14_2.07	1.899	2.08	2.07	6
IP10	Lateral 14	L14_2.199	2.09	2.815	2.199	9
IP11	Lateral 15	L15_23700	96	23701	23700	3
IP12	Lateral 15	L15_39170	23702	63282	39170	36
IP13	Lateral 17	L17_272	1	273	272	8
IP14	Lateral 17	L17_651	274	5571	651	10
IP15	Reach 2	R2_13840	5063	13840	13840	1
IP16	Reach 4	R4_2468	5	4903	2468	4
IP17	Reach 7	R7_3643	19	4498	3643	1
IP18	Toe Ditch	TD_20500	4000	21200	20500	1

Table 5. Number of structures and total damageable property value by structure category for the RD784 structure inventory

Structure category (1)	Number of structures (2)	Total damageable property ($1,000)[1,2] (3)
Single family, 1 story	103	12,247
Single family, 2 story	4	1,074
Mobile home	20	720
Commercial	2	1,162
Industrial	11	26,515
Public	1	8,555
Farm	7	5,158
Total	148	55,430

1. These values represent the depreciated replacement value as developed for the 2006 TRLIA analysis and updated to 2009 dollars.
2. Residential content is assumed 50% of residential structure value for this table. For EAD computations, the content damage is computed as a function of the structure value.

Table 6. Without- and with-project elevation-probability functions for CS-PLC

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)			
	IP1		IP2	
	Without-project (2)	With-project (3)	Without-project (4)	With-project (5)
0.999	39.92	40.07	40.39	41.22
0.500	41.10	41.08	42.87	42.74
0.200	41.42	41.36	43.55	43.15
0.100	41.59	41.50	43.90	43.37
0.040	41.84	41.68	44.28	43.68
0.020	41.96	41.79	44.42	43.86
0.010	42.07	41.89	44.54	44.01
0.005	42.16	41.99	44.68	44.13

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 7. Without- and with-project elevation-probability functions for Lateral 13

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)			
	IP3		IP4	
	Without-project (2)	With-project (3)	Without-project (4)	With-project (5)
0.999	43.59	44.51	44.57	46.87
0.500	45.35	45.16	47.37	47.14
0.200	45.99	45.34	48.13	47.21
0.100	46.32	45.43	48.53	47.25
0.040	46.71	45.67	49.05	47.48
0.020	46.82	45.81	49.19	47.61
0.010	47.14	46.06	49.56	48.07
0.005	47.41	46.22	49.72	48.28

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 8. Without-project elevation-probability functions for Lateral 14

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)					
	IP5 (2)	IP6 (3)	IP7 (4)	IP8 (5)	IP9 (6)	IP10 (7)
0.999	48.38	48.98	49.06	49.93	49.97	49.31
0.500	50.50	50.69	50.80	52.10	52.12	52.23
0.200	51.08	51.16	51.27	52.69	52.70	53.02
0.100	51.38	51.40	51.52	53.00	53.01	53.44
0.040	51.71	51.76	52.13	53.10	53.11	53.54
0.020	51.79	51.85	52.38	53.12	53.12	53.58
0.010	51.81	51.93	52.65	53.13	53.14	53.62
0.005	51.83	51.99	52.68	53.14	53.15	53.63

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 9. With-project elevation-probability functions for Lateral 14

Annual exceedence probability[1] (1)	**Elevation (ft NGVD29)**					
	IP5 (2)	**IP6 (3)**	**IP7 (4)**	**IP8 (5)**	**IP9 (6)**	**IP10 (7)**
0.999	48.81	49.41	49.47	50.44	50.48	50.21
0.500	50.50	50.69	50.80	52.10	52.12	52.24
0.200	50.96	51.04	51.16	52.55	52.57	52.79
0.100	51.20	51.22	51.35	52.79	52.80	53.08
0.040	51.38	51.40	51.51	52.95	52.95	53.28
0.020	51.49	51.51	51.63	53.03	53.03	53.40
0.010	51.62	51.64	51.80	53.07	53.07	53.49
0.005	51.67	51.69	51.91	53.09	53.09	53.52

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 10. Without- and with-project elevation-probability functions for Lateral 15

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)			
	IP11		IP12	
	Without-project (2)	With-project (3)	Without-project (4)	With-project (5)
0.999	36.62	36.59	49.61	47.27
0.500	38.98	37.64	52.46	50.24
0.200	39.62	38.26	53.23	51.05
0.100	39.96	38.59	53.64	51.47
0.040	40.33	38.84	53.86	52.02
0.020	40.60	38.98	54.02	52.36
0.010	41.97	40.57	54.39	53.13
0.005	42.19	42.35	54.49	53.51

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 11. Without- and with-project elevation-probability functions for Lateral 17

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)			
	IP13		IP14	
	Without-project (2)	With-project (3)	Without-project (4)	With-project (5)
0.999	54.04	54.04	49.59	47.92
0.500	54.05	54.05	52.58	50.86
0.200	54.73	54.58	53.39	51.67
0.100	55.08	54.85	53.82	52.09
0.040	55.62	55.43	54.06	52.62
0.020	56.03	55.85	54.22	52.95
0.010	56.39	56.20	54.57	53.55
0.005	56.71	56.49	54.66	53.83

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 12. Without- and with-project elevation-probability functions for Reach 2, IP15

Annual exceedence probability[1] (1)	**Elevation (ft NGVD29)**	
	Without-project (2)	**With-project (3)**
0.999	55.46	55.46
0.500	55.59	55.59
0.200	56.04	56.04
0.100	56.27	56.27
0.040	56.58	56.58
0.020	56.79	56.79
0.010	57.00	56.99
0.005	57.19	57.17

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 13. Without- and with-project elevation-probability functions for Reach 4, IP16

Annual exceedence probability[1] (1)	**Elevation (ft NGVD29)**	
	Without-project (2)	**With-project (3)**
0.999	50.29	50.29
0.500	52.87	52.25
0.200	53.72	52.97
0.100	54.17	53.35
0.040	54.45	53.78
0.020	54.60	54.05
0.010	54.95	54.38
0.005	55.05	54.55

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 14. Without- and with-project elevation-probability functions for Reach 7, IP17

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)	
	Without-project (2)	With-project (3)
0.999	52.38	52.38
0.500	53.46	53.27
0.200	54.18	54.03
0.100	54.55	54.42
0.040	54.71	54.63
0.020	54.83	54.74
0.010	55.00	54.86
0.005	55.08	54.92

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.

Table 15. Without- and with-project elevation-probability functions for Toe Ditch, IP18

Annual exceedence probability[1] (1)	Elevation (ft NGVD29)	
	Without-project (2)	With-project (3)
0.999	45.49	45.49
0.500	46.29	46.29
0.200	46.51	46.51
0.100	46.62	46.62
0.040	46.79	46.79
0.020	46.92	46.92
0.010	47.06	47.06
0.005	47.20	47.20

1. Values for the p=0.999 and p=0.200 events were graphically extrapolated.